

# Boating-Lightning Protection

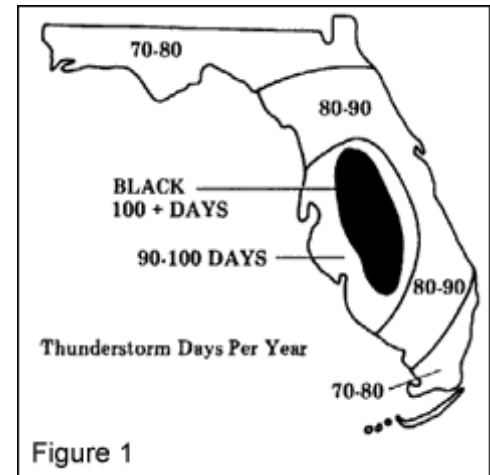
William J. Becker

*"One minute the fisherman was sitting atop his elevated seat aboard his boat. The next minute he was dead--the victim of a lightning bolt."*

*This was the lead paragraph in a recent Florida newspaper article. These accidents can and do happen--and yet they need not.*

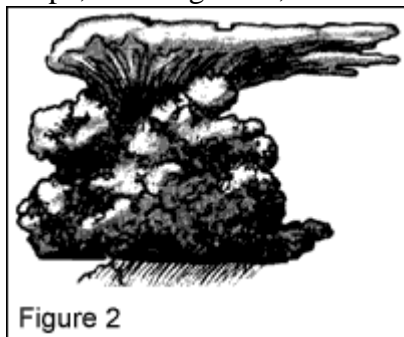
Florida has more thunderstorms--and thus, more lightning strikes--than any other state (see Figure 1). Only three states have a higher death rate from lightning than Florida, and no state has more deaths or injuries.

Florida averages more than ten deaths and thirty injuries from lightning per year. Approximately fifty percent of the deaths and injuries occur to individuals involved in recreational activities, and nearly forty percent of those are water-related: boating, swimming, surfing, and others. Those who enjoy Florida's waters certainly should understand the phenomena of thunderstorms--lightning and the precautions to take in order to keep these activities pleasurable--and how to prevent tragedy.



## LIGHTNING PHENOMENA

Most lightning strikes occur in the afternoon--70 percent between noon and 6:00 p.m. As the air temperatures warm, evaporation increases. This warm, moisture-laden air rises and evaporates, forming fluffy cumulus clouds. As more moisture accumulates, the clouds darken and change into cumulus nimbus clouds--thunderstorm clouds--frequently, with a flattened top or anvil shape, reaching to 40,000 feet or more (see Figure 2).



The upper portion of the cloud develops a positive electrical charge, the lower level a negative electrical charge. The air, because it is a poor conductor of electricity, restricts the regular flow of electricity between these, attracting electrical charges. While this phenomenon is occurring in the clouds, a similar phenomenon is occurring on the surface.

Negative charges repel negative charges and attract positive charges. So, as a thunder cloud passes overhead, a concentration of positive charges accumulates in and on all objects below the cloud. Since these positive charges are

attempting to reach the negative charge of the cloud, they tend to accumulate at the top of the highest object around. On a boat that may be the radio antenna, the mast, a fishing rod, or even you! The better the contact an object has with the water, the more easily these positive charges can enter the object and race upward toward the negative charge in the bottom of the cloud.

Lightning occurs when the difference between the positive and negative charges, the electrical potential, becomes great enough to overcome the resistance of the insulating air and to overcome the resistance of the insulating air and to force a conductive path between the positive and

negative charges. This potential may be as much as 100 million volts. To help you understand the magnitude of this voltage, the voltage needed in an automobile to cause a spark plug to fire is only 15 to 200 volts! And the spark plug gap is but a fraction of an inch!

Lightning strikes represent a flow of current from negative to positive, in most cases, and may move from the bottom to the top of a cloud, from cloud to cloud, or most-feared, from cloud to ground (see Figure 3). And when the lightning does strike, it will most often strike the highest object in the immediate area. On a body of water, that highest object is a boat. Once it strikes the boat, the electrical charge is going to take the most direct route to the water where the electrical charge will dissipate in all directions.

Let's consider a few possibilities. Lightning strikes the ungrounded radio antenna on your boat. The metal antenna carries the electrical charge to the radio, which does not have a good conductor to the water. Your hand is on the radio, or on metal connected to the radio. Your feet are on a wet surface, which is in contact with metal which extends through the hull of the boat to the water. Your body may then become the best conductor for the electrical charge.

A second example is a sailboat. Lightning strikes the mast. The electrical current follows the mast or wire rope to your hands, through your body to the wet surface, and then through the hull to the water.

Or, while operating a motor boat, the lightning strikes you, passes through your body to the motor, and then to the water.

Or, sitting in your aluminum or fiberglass rowboat, you are holding a graphite (a good electrical conductor) fishing rod. The rod is struck by lightning. The electrical charge passes through the rod, your body, then to the boat to the water.

In all four examples you could be seriously injured. You could be dead.

You need not even be in contact with the components of the boat struck by lightning. Unless the components of the boat which could conduct electricity are bonded together and are adequately grounded, there could be side flashes. A side flash occurs when the electrical charge jumps from one component to another seeking a better path to ground. You might be that "better path."

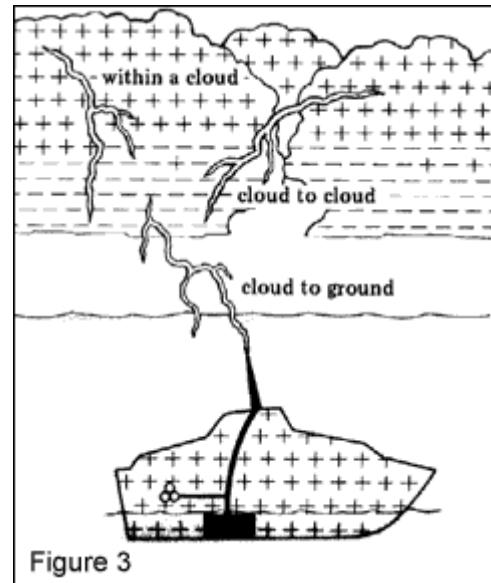


Figure 3

## MINIMIZE LIGHTNING STRIKE DAMAGE

Do not become a lightning target. Preferably stay off, and definitely get off, the water whenever weather conditions are threatening. Check the weather. The National Weather Service (NWS) provides a continuously updated weather forecast for Florida and its coastline via the VHF/FM channels WX1 (162.550 MHz), WX2 (162.400 MHz), WX3 (162.475 MHz). Never go boating without listening to this service. Their short-term forecasts are quite accurate, but small localized storms might not be reported. Therefore, it is important that boaters learn to read the weather.

Watch for the development of large well-defined rising cumulus clouds. Once they reach 30,000 feet the thunderstorm is generally developing. Now is the time to head for shore. As the clouds become darker and more anvil-shaped, the thunderstorm is already in progress.

Watch for distant lighting. Listen for distant thunder. You may hear the thunder before you can see the lightning on a bright day. Seldom will you hear thunder more than five miles from its

source. That thunder was caused by lightning 25 seconds earlier. The sound of thunder travels at one mile per five seconds (see Figure 4).

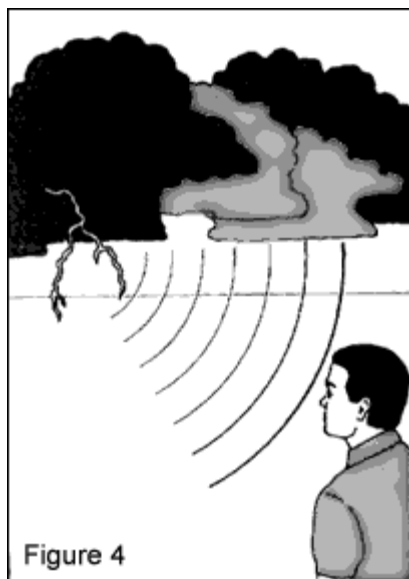


Figure 4

You are two miles from shore. The thunderstorm which is now five miles away is traveling in your direction at 20 miles per hour, which means it could be overhead within 15 minutes. Can you reach shore--two miles away--and seek shelter within that time? You better move!

## LIGHTNING-PROTECTED BOATS

There is no such thing as lightning-proof boats, only lightning-protected boats. All-metal ships are rarely damaged, and injuries or deaths are uncommon. These ships are frequently struck, but the high conductivity of the large quantities of metal, with hundreds of square yards of hull in direct contact with the water, causes rapid dissipation of the electrical charge. But small boats are seldom made of metal. Their wood and fiberglass construction do not provide the automatic grounding protection offered by metal-hulled craft. Therefore, when

lightning strikes a small boat, the electrical current is searching any route to ground and the human body is an excellent conductor of electricity!

Today's fiberglass-constructed small boats, especially sailboats, are particularly vulnerable to lightning strikes since any projection above the flat surface of the water acts as a potential lightning rod. In many cases, the small boat operator or casual weekend sailor is not aware of this vulnerability to the hazards of lightning. These boats can be protected from lightning strikes by properly designed and connected systems of lightning protection. However, the majority of these boats are not so equipped.

Lightning protection systems do not prevent lightning strikes. They may, in fact, increase the possibilities of the boat being struck. The purpose of lightning protection is to reduce the damage to the boat and the possibility of injuries or death to the passengers from a lightning strike.

If you are considering the purchase of a new or used boat, determine if it is equipped with a properly designed and installed lightning protection system. Such a system is generally more effective and less costly than a system installed on a boat after it has been constructed.

## LIGHTNING PROTECTION SYSTEM

The major components of a lightning protection system for a boat are an air terminal, main conductor, and a ground plate. Secondary components are secondary conductors, lightning arrestors, lightning protective gaps, and connectors (see Figure 5).

The mast, if constructed of conductive material, a conductor securely fastened to the mast and extending six inches above the mast and terminating in a receiving point, or a radio antenna can serve as the air terminal.

The main conductor carries the electrical current to the ground. Flexible, insulated compact-stranded, concentric-lay-stranded or solid copper ribbon (20-

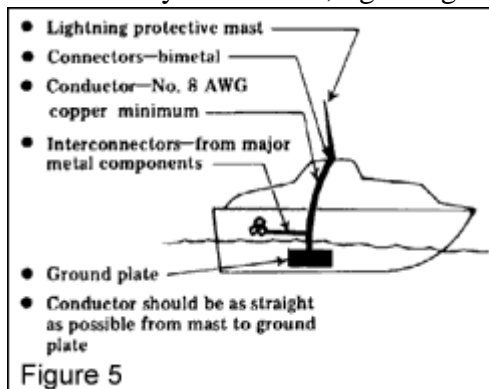


Figure 5

gauge minimum) should be used as the main conductor.

The ground plate, and that portion of the conductor in contact with the water, should be copper, monel or navel bronze. Other metals are too corrosive. The secondary conductors ground major metal components of the boat to the main conductor. However, the engine should be grounded directly to the ground plate.

Lightning arrestors and lightning protective gaps are used to protect radios and other electronic equipment which are subject to electrical surges.

The connectors must be able to carry as much electrical current as other components of the system. Further, the connections must be secure and noncorrosive.

On a large power boat or sailboat, a properly designed and grounded antenna could provide a cone of protection. Presently, however, the vast majority of the radio antenna is totally unsuitable for lightning protection. This is also true of the wires feeding the antenna. If the antenna is not properly grounded, it may result in injury or death and cause considerable property damage.

Sailboats with portable masts, or those with the mast mounted on the cabin roof, are particularly vulnerable as they are usually the least protected as far as grounding or bonding is concerned.

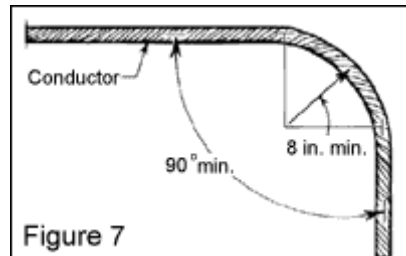
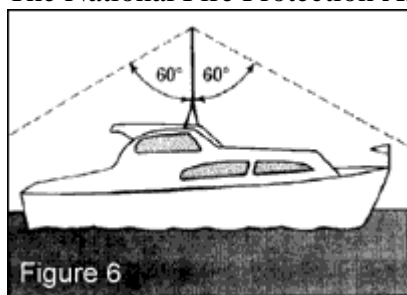
Ideally, an effective ground plate should be installed on the outside of all boats when the hulls are constructed. Unfortunately, this is not often done. Such a ground plate would help manufacturers design safer lightning protection systems for the boats.

## LIGHTNING PROTECTION CODE

The National Fire Protection Association, Lightning Protection Code, suggests a number of ways in which the boater can protect his boat and minimize damage if the boat is struck or is in the vicinity of a lightning strike.

These suggestions are summarized below:

- A lightning protective mast will generally divert a direct lightning strike within a cone-shaped radius two times the height of the mast. Therefore, the mast must be of sufficient height to place all parts of the boat within this cone-shaped zone of protection (see Figure 6).
- The path from the top of the mast to the "water" ground should be essentially straight. Any bends in the conductor should have a minimum radius of eight inches (see Figure 7).
- To provide adequate protection, the entire circuit from the top of the mast to the "water" ground should have a minimum conductivity equivalent to a No. 8 AWG copper conductor. If a copper cable is used, the individual strands should be no less than No. 17 AWG. Copper metal or strips should be a minimum of No. 20 AWG.
- Major metal components aboard the boat, within six feet of the lightning conductor, should be interconnected with the lightning protective system with a conductor at least equal to No. 8 AWG copper. It is preferable to ground the engine directly to the ground plate rather than to an intermediate point in the lightning protection system.
- If the boat's mast is not of a lightning protective design, the associated lightning or grounding connector should be essentially straight, securely fastened to the mast, extended at least 6 inches above the mast and terminate in a sharp receiving point.



- The radio antenna may serve as a lightning protective mast, provided it and all the grounding conductors have a conductivity equivalent to No. 8 AWG copper and is equipped with lightning arrestors, lightning protective gaps, or means for grounding during electrical storms. Most antennas do not meet these requirements. The height of the antenna must be sufficient to provide the cone-shaped zone of protection.
- Antennas with loading coils are considered to end at a point immediately below the loading coil unless this coil is provided with a protective device for by-passing the lightning current. Nonconducting antenna masts with spirally wrapped conductors are not suitable for lightning protection purposes. Never tie down a whip-type antenna during a storm if it is a part of the lightning protection system. However, antennas and other protruding devices, not part of the lightning protection system, should be tied down or removed during a storm.
- All materials used in a lightning protective system should be corrosion-resistant. Copper, either compact-stranded, concentric-lay-stranded or ribbon, is resistant to corrosion.
- The "water" ground connection may be any submerged metal surface with an area of at least one square foot. Metallic propellers, rudders or hull will be adequate.
- On sailboats, all masts, shrouds, stays, preventors, sail tracks and continuous metallic tracks on the mast or boom should be interconnected (bonded) and grounded.
- Small boats can be protected with a portable lightning protection system. This would consist of a mast of sufficient height to provide the cone of protection connected by a flexible copper cable to a submerged ground plate of at least one square foot. When lightning conditions are observed in the distance, the mast is mounted near the bow and the ground plate dropped overboard. The connecting copper cable should be fully extended and as straight as possible. The boaters should stay low in the middle or aft portion of the boat.

## WHEN CAUGHT IN A STORM

Thunderstorms in Florida and over its coastal waters are frequently unpredictable. Even with the best weather reports, along with constant and accurate observations of climatic conditions, boaters can still be caught in open waters in a thunderstorm. Then, with or without a lightning protective system, it is critical to take additional safety precautions to protect the boat's personnel. These precautions during a thunderstorm are:

- Stay in the center of the cabin if the boat is so designed. If no enclosure (cabin) is available, stay low in the boat. Don't be a "stand-up human" lightning mast!
- Keep arms and legs in the boat. Do not dangle them in the water.
- Discontinue fishing, water skiing, scuba diving, swimming or other water activities when there is lightning or even when weather conditions look threatening. The first lightning strike can be a mile or more in front of an approaching thunderstorm cloud.
- Disconnect and do not use or touch the major electronic equipment, including the radio, throughout the duration of the storm.
- Lower, remove or tie down the radio antenna and other protruding devices if they are not part of the lightning protection system.
- To the degree possible, avoid making contact with any portion of the boat connected to the lightning protection system. Never be in contact with two components connected to the system at the same time. Example: The gear levers and spotlight handle are both

connected to the system. Should you have a hand on both when lightning strikes, the possibility of electrical current passing through your body from hand to hand is great. The path of the electrical current would be directly through your heart--a very deadly path!

- It would be desirable to have individuals aboard who are competent in cardiopulmonary resuscitation (CPR) and first aid. Many individuals struck by lightning or exposed to excessive electrical current can be saved with prompt and proper artificial respiration and/or CPR. There is no danger in touching persons after they have been struck by lightning.
- If a boat has been, or is suspected of having been, struck by lightning, check out the electrical system and the compasses to insure that no damage has occurred.

## **SUMMARY**

- Boating in Florida's waters is an enjoyable activity for many people. Keep it that way!
- Listen to the weather reports! Learn to read the weather conditions. Heed these reports and the conditions. Stay off or get off the water when weather conditions are threatening.
- Install and/or maintain an adequate lightning protection system. Have it inspected regularly. Follow all safety precautions should you ever be caught in a thunderstorm. By using good judgement, it is less likely that first aid or CPR will be needed while boating.

## **REFERENCES**

- National Fire Codes. Lightning Protection Code--NFPA 78; Fire Protection Standard for Motor Craft--NFPA 302, 14. National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.
- Standards and Recommended Practices for Small Craft. Standard E-4, Lightning Protection. American Boat and Yacht Council, P.O. Box 806, Amityville, NY 11701.
- Sitarz, Walter A. Boating Safety--Thunderstorms (MAP-5), Florida Sea Grant College Program, University of Florida, Gainesville, FL 32605.

## **ACKNOWLEDGEMENT**

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*This document, SGEB-7, was published May 1985 and last reviewed October 1992 by the Florida Cooperative Extension Service. For William J. Becker, Professor and Extension Safety Specialist, Agricultural Engineering Department, Cooperative Extension Service, Institute of Food*